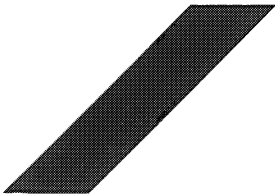**Adaptation of space remote sensing technology to diagnostic imaging highlights spinoffs in the field of health and medicine**

New Window Into the Human Body

nuclear magnetic resonance (NMR) is a relatively new technique for viewing the inner parts of the human body. Instead of possibly dangerous x-rays, it employs a magnetic field and radio waves to create body images from which radiologists can extract diagnostic information. It offers certain advantages over other body-scanning systems, for example, it is noninvasive and it can penetrate bone, which normally blocks x-rays. NMR also has its limitations because it has not yet been fully developed; although NMR equipment is being produced commercially and the images used clinically, NMR is still largely an experimental technique being studied and advanced by a number of medical institutions.

NMR images provide a vast amount of anatomical and physiological information, which is at once an advantage and a disadvantage. The disadvantage is that the NMR scanner collects a great amount of redundant data, inducing a degree of complexity that makes interpretation difficult. In some instances, where a patient has a complicated problem, a radiologist may have to analyze 50 or more NMR images to make a proper diagnosis.

Seeking a way to overcome this difficulty, Michael Vannier, M.D., hit upon the idea of employing satellite image enhancement technology. Dr. Vannier is now assistant professor of radiology at Mallinckrodt Institute of Radiology, Washington University Medical Center, St. Louis, Missouri, but in earlier life he was a NASA engineer. Thus, he was able to recognize the similarities between NMR imaging and the space technique of Earth resources imaging. The NASA-developed Landsat satellite takes electronic pictures in several segments of the light spectrum. Its detectors recognize unique "signatures" of various Earth features—crops, water, buildings or forests—and send the information to ground stations in a voluminous flow of digital data. By itself, the raw data would be extremely difficult to interpret, but use of NASA's computerized image processing technology makes possible easier analysis. A computer program analyzes the data, sharpens contrasts, eliminates confusing detail and produces Earth images in which the various features appear in different colors.

Dr. Vannier contacted NASA to see if Landsat processing techniques could be applied to medical imagery. He enlisted the help of Bob Butterfield, manager of technology integration at Kennedy Space Center, and Douglas Jordan, engineering manager of the Remote
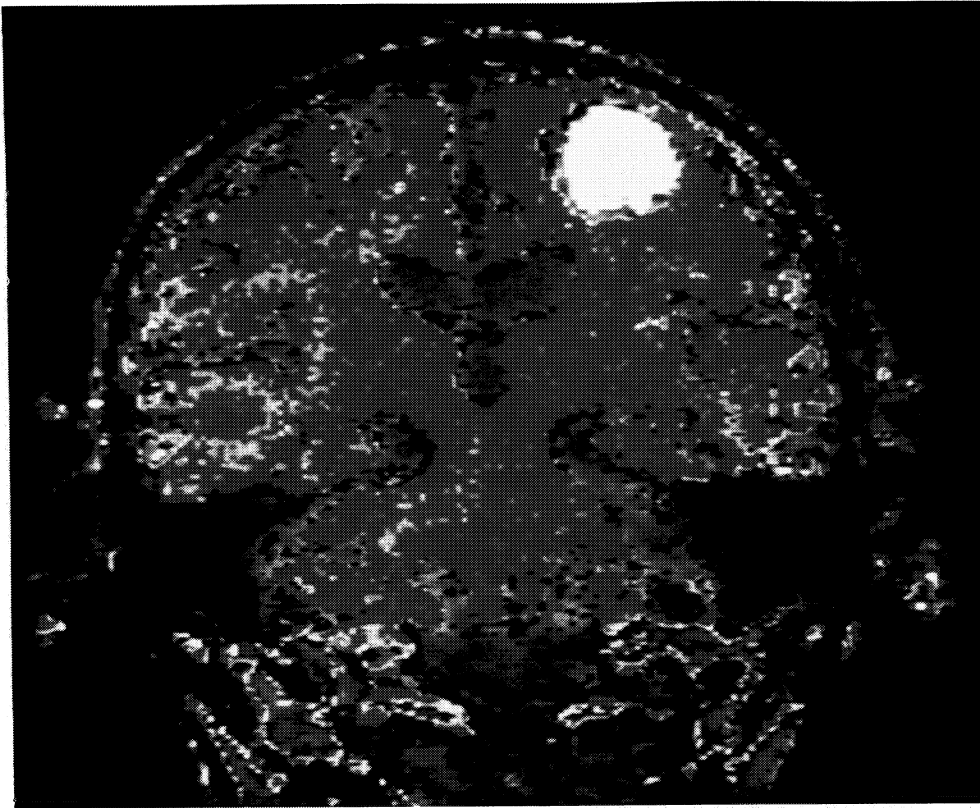
Nuclear magnetic resonance (NMR) is a promising new technique for diagnostic body scanning, but NMR imagery is difficult to interpret. Space image enhancement technology offers a means of improving black and white NMR images and facilitating earlier diagnoses. The upper image is a computer processed color composite of an NMR head scan, showing a brain tumor (white area near top). In the lower image the enhancement process is taken a step further to create a "theme map" in which each color corresponds to a different type of tissue, with the tumor sharply defined.
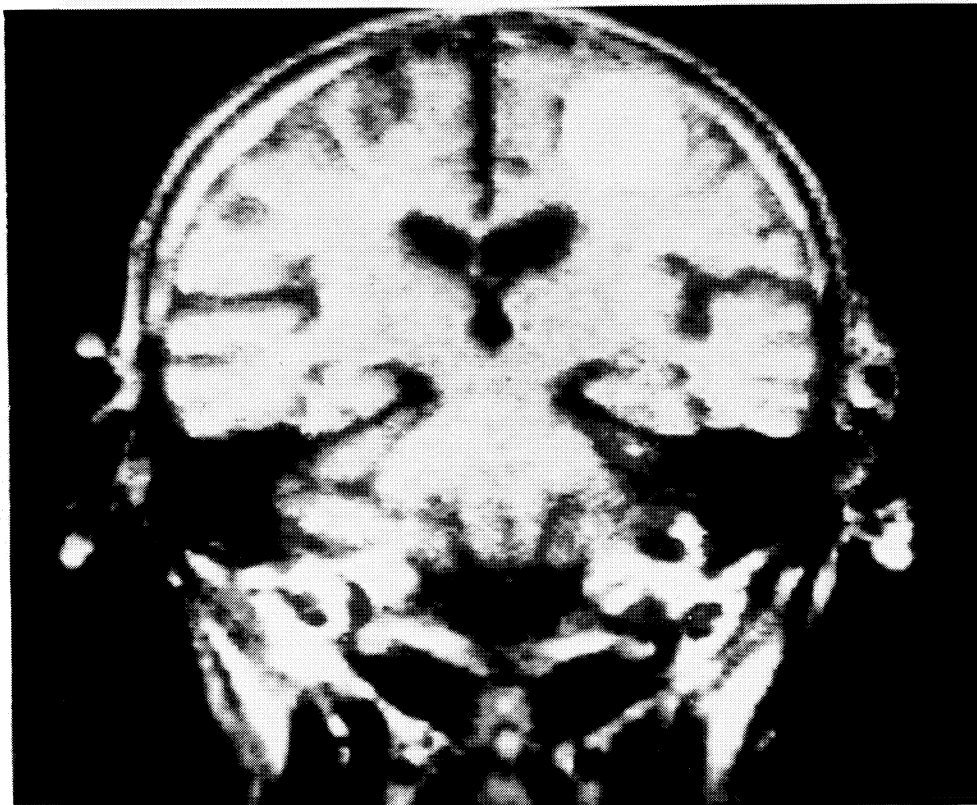
Sensing and Image Processing Laboratory at the University of Florida in Gainesville. Dr. Vannier and Butterfield took a number of NMR scans to the Florida laboratory, which has a highly sophisticated computer used in analysis and classification of Landsat data. The computer program processed the NMR scans just as it would Landsat information, combining multiple black and white NMR images into a single, realistically-colored composite picture. "These pictures look real," says Dr. Vannier, "just as if you lifted a slice right out of the human body."

The trio of Vannier, Butterfield and Jordan, with help from other representatives of their three organizations, took their research one step further and learned how to make "theme maps" of the human body. In Earth resources observation, Landsat signature data can be processed to create a thematic image, for example, one that separates wheat fields from all other crop areas. In medical use, the computer program searches the NMR image for a signature of interest to the radiologist—a hematoma, or blood clot in the brain, perhaps—and colors any area that has that particular signature. In the hematoma example, the resulting theme map shows the precise demarcation between the blood clot and the parts of the body still unaffected, where original NMR scans define such borders poorly. Such tissue maps should facilitate earlier diagnosis in many disorders.
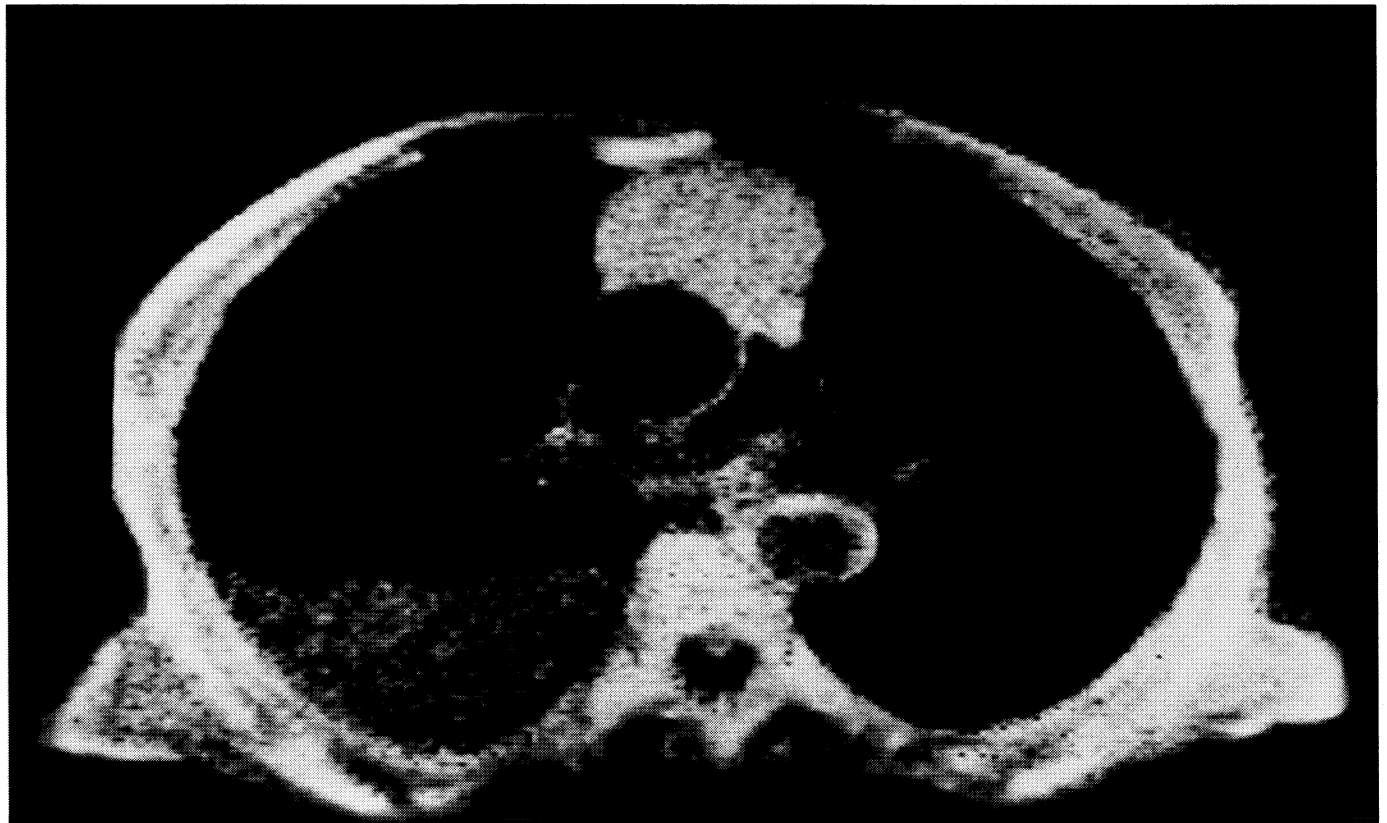
Dr. Vannier has collaborated with other physicians in applying satellite technology to NMR scanning in scores of patient studies. He is now engaged in advancing the process one more step: converting the Landsat computer program to a form compatible with the type of computer integral to the NMR system; that would allow expansion of the new imaging technique to all NMR centers.

The Mallinckrodt Institute radiologist feels that satellite image processing will become a regular part of NMR body scanning, although it may be in a much different form than in the initial applications. "Even these first crude experiments show that the potential is very great," he says. "Satellite imaging has opened a new window into the human body."
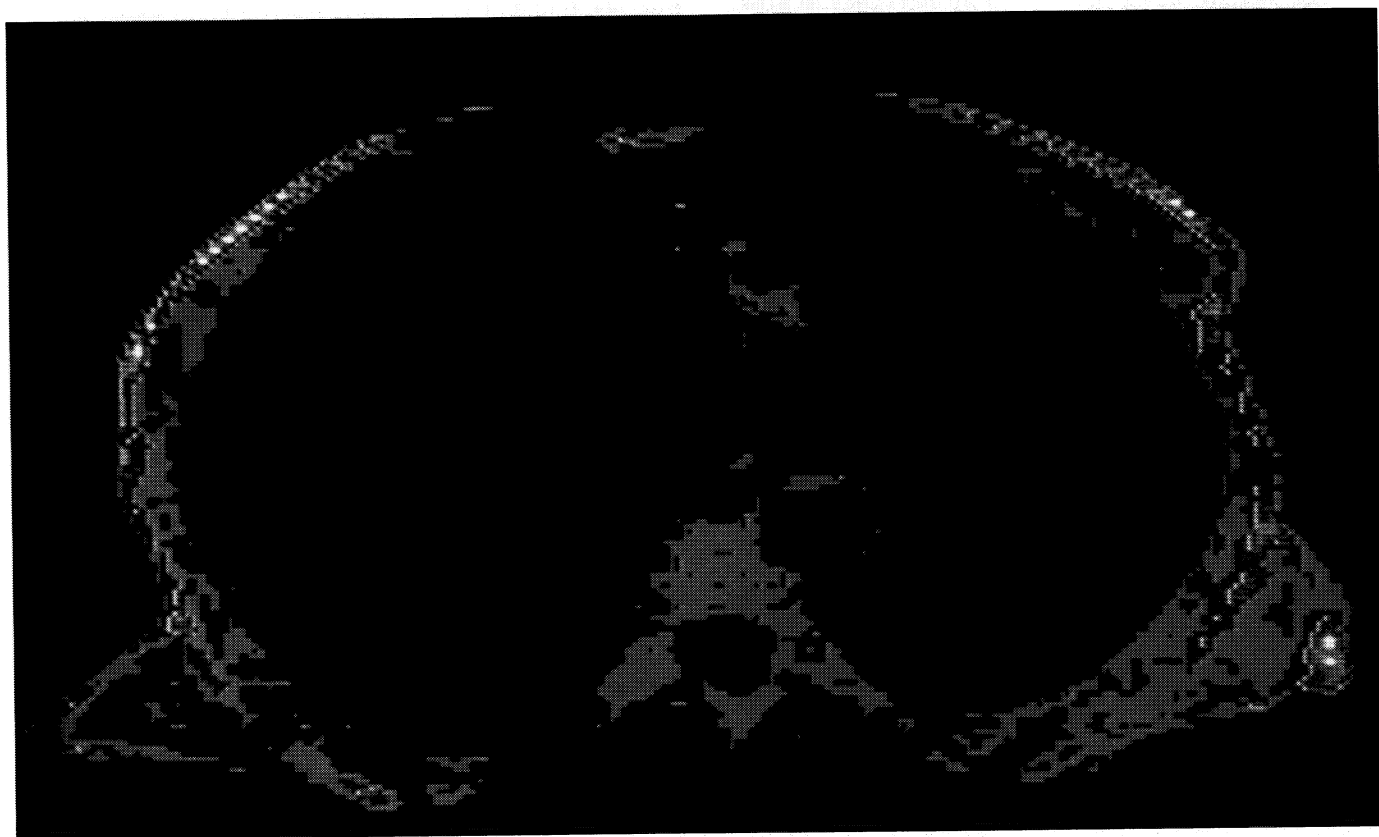
A space-developed computer program created the color composite at left from three black and white NMR images. It is a chest scan showing a tumor mass at top center. In the theme map at right, the borders of the tumor mass (top center) are precisely outlined.